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UCS INTENSITY AND THE PARTIAL REINFORCEMENT EXTINCTION EFFECT
OF THE EYELID RESPONSE IN THE RABBIT

by



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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "UCS intensity and the partial reinforcement extinction effect of the eyelid response in the rabbit", submitted by Stanley Melbourne Kolber in partial fulfilment for the requirements for the degree of Master of Science.

Abstract

The partial reinforcement extinction effect (PRE) is well known in classical human eyelid conditioning. Until recently, no attempt has been made to explain this phenomenon. Spence (1963; 1966b) suggested that the subject of a continuously reinforced group was aware of the change from acquisition to extinction and thereby adopted a cognitive set "not to respond". By reducing the subject's awareness of this change, the performance during extinction became a gradual rather than a rapid decrement. Theoretically, one might expect this finding with infrahumans because of their presumed inability to develop these cognitive sets. This hypothesis was supported in a study by Thomas and Wagner (1964) using rabbits which were conditioned under one UCS intensity level. This present study was an attempt to replicate Thomas and Wagner's finding under different UCS intensity levels.

The eyelid response of the New Zealand albino rabbit was classically conditioned with a tone as the CS and an airpuff as the UCS which was at intensity levels of 75, 150, and 250 mm Hg.

The percentage reinforcement x trials interaction was not significant. This was in accord with Thomas and Wagner's findings. The percentage reinforcement x intensity x trials interaction was significant. Here intensity interacted with percentage reinforcement to produce a PRE. Since the 75 PR and the 250 PR groups showed little acquisition however, the significance of this interaction seems due to the fact that no loss was possible, and therefore, does not really reflect a PRE. A number of reasons were presented in an attempt to explain this low level of performance.

Acknowledgements

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Stanley Melbourne Kolber

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Partial reinforcement extinction (PRE) effect is well known in human eyelid conditioning. This term refers to the phenomenon whereby continuously reinforced (CRe) subjects (Ss) extinguish faster than partially reinforced (PR) Ss. Originally, this phenomenon was thought to have challenged Hull's general behavior theory (1943). Hull postulated that with each reinforced trial a unit of habit strength was added to that response, and that the amount of habit determined the strength of the tendency to give a response. At the termination of an arbitrary number of trials, the strength of the response of the CRe Ss would be twice the strength of the response of the PR Ss under 50% reinforcement. During extinction, then, the CRe Ss would be more resistant to extinction than the PR Ss. Just the opposite occurs, however (e.g. Grant and Schipper, 1952; Reynolds, 1958). Spence (1963; 1966b) has attempted to explain this phenomenon. He believed that a human S in the CRe conditions was aware of the change from acquisition to extinction procedures and thereby adopted a cognitive set "not to respond". This resulted in a rapid decrement during extinction. If one could reduce S's awareness of this change, such as by training under partial reinforcement, then the performance during extinction should be a gradual rather than a rapid decrement. Theoretically, one might also expect to find gradual extinction following both CRe and PR with infrahumans because of their presumed inability to develop these cognitive sets. In a recent investigation of the conditioned eyelid response in the rabbit, Thomas and Wagner (1964) found no difference between the extinction decrements of CRe and PR Ss when one unconditioned stimulus (UCS) intensity level was used, thus supporting this view.

The purpose of this study was to extend their findings to different UCS intensities.

From a consideration of the results of a number of studies, mostly using human Ss, it is possible to predict what the results might be. Spence (1958) found that during acquisition performance of the CR, Ss increased with increasing UCS intensity. The same effect should be observed with PR Ss; however, recent evidence (Boice and Boice, 1966; Foth, 1968) indicates that UCS intensity may interact complexly with other variables involving reinforcement schedules. On the basis of this evidence, Spence's theory (1963; 1966b), and Thomas and Wagner's (1964) results one might expect to find a complex relationship occurring between UCS intensity and percentage reinforcement during acquisition, and no PRE occurring during extinction.

Much work has been undertaken to delineate the variables involved in the PRE and UCS intensity conditions. What follows is a consideration of these variables.

PRE studies

Relevant investigations have shown that partial reinforcement seriously interferes with acquisition performance in human eyelid conditioning. In this respect, according to Kimble (1967, pp. 651-652) and Spence (1966b, p. 446), such learning differs from instrumental learning where PR often produces better performance (Goodrich, 1959). Therefore, only purely classical conditioning studies will be reviewed here.

Work on the PRE phenomenon began with Humphrey's studies (1939a and 1939b: 1940) utilizing a verbal response technique. The S faced

a screen containing two lamps. The left lamp (the CS) was consistently turned on by the experimenter and sometimes five seconds later it was followed by the right light (the UCS), and sometimes not. The Ss were instructed to guess whether or not the left light would be followed by the right light. Thus, their responsive anticipation of the right light served as the conditioned responses (CRs). Hake, Grant, and Hornseth (1951) suggested that the experiments using this technique were not completely analogous to the eyelid CR. These studies are being included to indicate the direction which this line of research took. Further studies attempted to discover the factors in the sequence of trials which affected resistance to extinction in PR situations (Hake, and Grant, 1951; Hake, Grant, and Hornseth, 1951).

Later, researchers began extensively using the human eyelid conditioning technique to study the parameters involved in the PRE. Many of these studies using the standard experimental situation* were successful in obtaining a PRE. In these studies, when the number of acquisition trials was held constant, a PRE was obtained when from two to five different percentages of reinforcement were used (Capaldi, 1957; Grant, Hake, and Hornseth, 1951; Grant, Hornseth and Hake, 1950; Grant and Schipper, 1952; Grant, Schipper, and Ross, 1952; Hartman and Grant, 1960; Reynolds, 1958). One study using two different percentages of reinforcement under comparable conditions failed to find a PRE (Froseth and Grant, 1961). Again, under comparable conditions, Hartman

* Whenever the "standard experimental situation" is mentioned, the type of study involved is merely a parametric one where the dependent variable, such as percentage reinforcement, is studied over a number of trials.

and Grant (1960) and Reynolds (1958) found a PRE when CRe and PR Ss were each given the same number of reinforced trials (thus resulting in more actual trials for the PR group). The PRE has been investigated with other techniques, as well. A PRE was found with both the GSR technique (Grant, Meyer, and Hake, 1950) and with the conditioned heart-rate technique (Notterman, Scheonfeld, and Bersh, 1952) in standard experimental situations. Studies using the latter two techniques have not been extensively pursued.

Using eyelid conditioning, two studies have failed to find the PRE. This was the case when severely retarded children were used as Ss (Ross, Koski, and Yaeger, 1964), and when the intensity of the UCS was varied from trial to trial (Passey and Burns, 1962). In the latter study a CRe and a 50% PR group were used. The UCS was of two different intensities, with their order of presentation being randomized on the reinforced trials, that is, either UCS intensity would appear on each reinforced trial for the CRe and the PR Ss. In addition, for the latter group, the reinforced trials would be interspersed with unreinforced trials.

Regarding the acquisition data of the previously mentioned studies, in the majority of cases the CRe Ss performed better than the PR Ss. This was also the finding in an interesting and important study by Ross (1959). Four groups were used: a CRe group, a PR group, a CRe group which was switched to a PR group mid-way through the experiment, and a PR group which was switched to a CRe group mid-way through the experiment. Acquisition only was given. The CRe and the PR Ss behaved as expected, however, the performance of the CRe Ss, when switched to part-

ial reinforcement, fell immediately from the normal CRe level to the PR level. The performance of the PR Ss, when switched to continuous reinforcement, slowly rose from the normal PR level to the CRe level. This study was important because it influenced Spence to take a closer look at partial reinforcement phenomenon and then to develop his theory.

Spence's main concern was with the more rapid extinction of the CRe Ss. In 1962, Goldstein performed the standard experiment comparing PR and CRe conditions. Following the extinction procedure, he questioned his Ss. Goldstein found that practically all Ss reported that they recognized the change in conditions that occurred with the shift from acquisition to extinction. It was on the basis of this information that Spence (1963; 1966b) attempted to explain the PRE phenomenon. He hypothesized that human CRe Ss, on noticing the change in stimulus conditions, became aware that their eyelid has become conditioned and thereupon more or less immediately adopt a set not to blink to the CS. Under PR, on the other hand, S has experienced nonreinforcements on some portion of the acquisition trials. Hence, the shift to extinction for this S should not be as noticeable as the shift to extinction for the CRe S.

To further test this theory, Spence attempted to reduce S's recognition of this change in stimulus conditions by employing a masking situation in which the CS - UCS presentations are contained within a more complex series of events. The consequence of this technique should be a gradual rather than a rapid response decrement for the CRe Ss, and therefore, the disappearance of the PRE.

The typical masking situation is in the form of a probability

learning game. This situation involved a centrally placed light which, when it came on, was the signal for S to anticipate within its duration which of two small bulbs, one to the left and one to the right of the signal light, would subsequently light. The Ss were instructed that their task was to predict which of the two small lamps would light and to signify their prediction by pressing the button on the left or right arm of the chair. In addition, they were told that distracting stimuli in the form of a tone and airpuff to the eye would be presented between their responses of pressing a button and the lighting of one of the lamps. The onset of the tone coincided with the offset of the signal light. The small lamps lit according to a prearranged schedule. Thus, the relation between the CS (tone) and UCS (airpuff) was presumably masked by the complexity of events co-occurring with the conditioned stimuli.

The studies using this technique have shown the rate of extinction to be reduced compared with the rate found in the standard conditioning situation (Spence, 1963; Spence, 1966a; Spence, Howzie and Rutledge, 1964), and that no difference was found between the CRe and the PR Ss in both acquisition and extinction (Spence and Platt, 1967).

Spence suggested that a number of previous experiments would further support his contention. In these studies, S's cognitive ability was shown to be influenced by the experimenter thereby resulting in a change in S's performance level. The results of Grant (1939) and Miller (1939), showed that instruction-produced sets will facilitate or inhibit S's level of response. In Passey and Burn's (1962) study the varying of the intensity of the UCS by the experimenter from trial to trial during

acquisition made the shift from acquisition to extinction procedures more difficult for the S to notice. It is significant also that Ross, Koski, and Yaeger (1964), using mental retardates who presumably are not as cognitively capable, reported that the CRe Ss extinguished at the same rate as those who received continuous reinforcement.

Spence and Platt (1967) sought further evidence from studies involving infra-humans. They suggested the studies where the PRE was obtained

resulted, either from the fact that the behavior situations had involved instrumental response components or conditions were particularly favorable for some form of stimulus after-effects mechanism, such as the Hull-Sheffield hypothesis assumes. (p. 261).

They are suggesting, if Spence's explanation of the PRE is true, that the results from human Ss using the masking technique should be similar to classical conditioning studies with infrahumans. If the results differ, one may conclude a) the explanation for humans differs from the explanation for infrahumans, or b) there is an alternative theory which explains the results of all species.

The data from studies using infrahumans are presently not sufficient evidence to justify any conclusions drawn from them, although, clearly the PRE effect is difficult to obtain with some species. A frequent finding during extinction is that there is no difference between the two groups. Using the standard experimental situation, this result was found with goldfish (Gonzalez, Longo, and Bitterman, 1961, exp. 1; Gonzalez, Milstein, and Bitterman, 1962, exp. 1, 2, and 3; Berger, Yarczower, and Bitterman, 1965, exp. 2 and 3) with dogs (Fitzgerald, 1966, exp. 1; Wagner, Seigel, Thomas, and Ellison, 1964), with

rats (Armus, 1960; Wagner, Seigel, and Fein, 1967, exp. 1), with pigeons (Longo, Milstein and Bitterman, 1962), and with rabbits (Bruner, 1965; Thomas and Wagner, 1964). The CRe Ss showed better performance during extinction on one occasion (Berger, Yarczower, and Bitterman, 1965, exp. 1).

There were a number of successful studies obtaining the PRE, however. With trials equated, the PRE was found with dogs (Fitzgerald, 1963; Fitzgerald, Vardaris, and Teyler, 1966), with rats (Wagner, Seigel and Fein, 1967, exp. 2) and with earthworms (Wyers, Peeke, and Herz, 1964). With reinforcements equated, successful results were obtained with the mouthbreeder (Gonzalez, Eskir, and Bitterman, 1963, exp. 1) and with dogs (Fitzgerald, 1966, exp. 2). A PRE was also found with goldfish (Berger, Yarczower, and Bitterman, 1965, exp. 4 - 7), after long runs of unreinforced trials which tended to come early in the experimental session.

Few conclusions can be drawn at this time regarding the conditions necessary for the appearance of the PRE in infrahumans. The only systematic study of this problem was with the mouthbreeder and the goldfish. Here, one can conclude that the PRE seems to have appeared consistently with the mouthbreeder, but not with the goldfish. The results of the dog-studies are ambiguous. In one study (Fitzgerald, Vardaris, and Teyler, 1966), a PRE was found, and in another (Fitzgerald, 1966, exp. 1) no difference between the CRe and the PR Ss was found. The fact that the PRE is found at all, however may call cognitive theories into question, unless Spence's criticisms (Spence and Platt, 1967) are correct.

UCS intensity studies

The role of UCS intensity in classical conditioning was first

studied by Pavlov (1927). He performed a series of systematic studies dealing with the effects of stimulus intensity upon the size of the conditioned response and the ease with which it could be extinguished. Pavlov found that the UCS must be of a certain magnitude before it was effective. Above this intensity, an increase in strength serves to increase the amplitude of the resulting conditioned responses and to prolong the number of unreinforced presentations necessary to extinguish the response. Pavlov also found an upper limit of UCS intensity beyond which there is a decrement in the amplitude of the response and a decrease in the number of unreinforced trials necessary for extinction. In a review of later Russian experiments, Razran (1957) found Pavlov's findings to be essentially confirmed.

Hull (1943) indirectly incorporated the effects of UCS intensity into his model. He postulated that the excitatory potential, \underline{E} , determining the strength of a response is a multiplicative function of a learning factor, \underline{H} , and a generalized drive factor, \underline{D} , that is,

$$\underline{D} \times \underline{H} = \underline{E}$$

The effects of UCS intensity was considered to act on \underline{D} .

Spence (1958) developed this model further for use in his classical eyelid conditioning studies. The operational measure of \underline{E} was the frequency of CRs produced by the organism. \underline{H} was determined by the number of trials given to the organism. \underline{D} was assumed to be a positive function of the magnitude or strength of a hypothetical response mechanism. The latter refers to a persisting emotional response, \underline{r}_e , in the organism which could be aroused by any aversive stimulation, such as shock or an airpuff. Individuals were thought to differ characteristically in the magnitude of \underline{r}_e exhibited to the same intensity

of stressful stimuli. Increased changes in this aversive stimulation should, furthermore, produce increased changes in r_e , \underline{D} , and ultimately \underline{E} . If one increased UCS intensity one should increase the frequency of CRs produced by the organism.

The followers of Hull began systematic UCS intensity studies, and amassed evidence supporting their assumption that UCS intensity acted on drive to produce a growth in habit-strength (Beck, 1963; Passey, 1948; Passey and Burns, 1962; Ross and Hunter, 1959; Spence, 1953 and 1956, pp. 172 - 176; Spence, Haggard, and Ross, 1958a and 1958b; Trapold and Spence, 1960; Walker, 1960).

Further studies revealed the relationship between performance and UCS intensity was a negatively-accelerated one that approached an asymptote within a relatively small range of puff intensity values (Reynolds, 1958; Ross and Spence, 1960; Spence, 1953, 1958; Spence and Ross, 1959).

However, it was not clear whether UCS intensity acted upon \underline{H} or \underline{D} . It was only assumed that UCS intensity acted upon \underline{D} . Spence (1953) investigated this problem. Two groups of \underline{S} s were used. One group was conditioned to a visual CS reinforced with a weak UCS and the other group was conditioned to the same CS reinforced with a strong UCS. On Day 1, each group was given the same number of conditioning trials. On the second day of training, the two groups were each divided into two subgroups with half of the \underline{S} s continuing with the same UCS and half being switched to the other intensity. Response measures obtained on Day 2 provided the data. Spence argued that a comparison of the two subgroups who received the strong UCS on Day 1 with the two subgroups who received the weak UCS on Day 1 would reflect possible differences in habit

strength. Possible differences in drive strength would be reflected by a comparison of the two subgroups who received the strong UCS on Day 2 with the two subgroups who received the weak UCS on Day 2. The results for both comparisons indicated that the subgroups receiving the strong UCS performed significantly better than the subgroups receiving the weak UCS. These results were interpreted to mean that UCS intensity affected both H and D. Spence, Haggard, and Ross (1958a) suggested that it was possible to interpret these findings in terms of a differential drive level based on fear responses of different strength that become conditioned to the cues of the experimental situation. They re-evaluated the problem of whether UCS intensity affects H or D or both. In their experiment, they attempted to equate S's level of drive during the course of the conditioning session and at the same time provide for differential reinforcement. The high reinforcement Ss had a visual CS paired with a strong puff on 50 or 100 trials and a weak puff was presented on the remainder of the trials without the CS. The procedure for the low reinforcement Ss was reversed. Since the two groups received the same average intensity of the UCS throughout the training period, their drive levels would be equated. However, the intensity of the puff on the trials on which conditioning could occur differed for the two groups. The group that had a strong puff on the trial on which conditioning could occur should develop a greater amount of habit strength than the group that had a weak puff on a conditioning trial. The results showed the high reinforcement Ss performed significantly better than the low reinforcement Ss despite the presumed equality of drive. They concluded, on the basis of their results, that UCS intensity acts

on H. On the basis of Spence's (1953) results, one may conclude that UCS intensity acts on D, as well.

Following the Spence, Haggard, and Ross (1958a) study, Ross and Hunter (1959) addressed themselves to the question of whether performance curves for Ss reinforced with a weak UCS would ever catch up with the curve for Ss reinforced with a strong UCS. (One could not deduce this from the previous studies because the two groups had not reached stable asymptotic performance levels.) Using the same procedures and puff intensities, their Ss were given 100 trials with either a strong or a weak puff; an equal number of trials with the opposite UCS were given alone. Their results showed that it is asymptotic performance rather than the rate of growth that varies as a function of the UCS.

UCS intensity has been shown to have different effects on low and high anxious Ss as defined by scores on the Taylor Manifest Anxiety Scale (Spence, 1958; Spence and Taylor, 1951; Spence and Weyant, 1960) when the standard experimental situation was used. The performance of high anxious Ss was greater than the performance of low anxious Ss for any intensity level. In addition, if more than one intensity level was used, maximum performance differences between the high and low anxious Ss were obtained with the strongest UCS intensity level. Anxiety differences have been interpreted as reflecting differences in drive level.

In the only experiments using infrahumans, Annau and Kamin, (1961) found the acquisition of the conditioned emotional response (CER) of rats and its resistance to extinction to be increasing

monotonic functions of the UCS intensity employed in training. Again using the CER of rats, Kamin and Brimer (1963) varied CS and UCS intensities. Using a given CS intensity, increasing the UCS intensity will result in a monotonic change of performance.

Spence's theory has recently been challenged. Prokasy (1967) suggested that there was only marginal support for Spence's view that the relationship of D to H is multiplicative. Even though performance is greater for high D, effects such as individual differences and divergence between groups across trials, which can be predicted from his theory, have not been obtained. Later in his paper, Prokasy softened his criticism and stated

... the difficulty is that we have no independent means of knowing how independent-variable manipulations relate to the constructs of the theory. In absence of this knowledge, the relationships have been assumed in order to make experimental predictions. The consequence of this is that a failure of data to conform to expectation may reflect our ignorance of the correlation between empirical operations and various theoretical parameters rather than an inadequacy of the theory. (p. 375)

Prokasy concluded that the question "do D and H multiply to determine performance in human conditioning?" cannot be answered unequivocally. He did not suggest an alternative to Spence's theoretical constructs, however.

The importance of the UCS intensity variable has recently been questioned. Burstein (1965) argued that there was no convincing evidence to support the conclusion that there are significant effects of varied UCS intensity upon performance. All previous data, according to Burstein, unjustly included nonconditioners, and when these were eliminated, the results became nonsignificant. UCS intensity, how-

ever, determines whether an individual S will, or will not, condition. Thus, more Ss will condition with a high UCS intensity than with one of low intensity. Burstein's argument was strongly attacked by Spence and Platt (1966). They re-analyzed many of the previous studies with and without the nonconditioners. The findings from the individual experiments did not change. Spence and Platt suggested that Burstein's results were nonsignificant because the performance had already reached an asymptotic level. Therefore, Burstein was using intensity values that were ineffective in producing a significant difference without a large number of Ss.

Burstein (1967) retorted that Spence and Platt's re-analysis had not used the same criterion set up for the elimination of nonconditioners as he had previously mentioned (1965). Suboski (1967) then used Burstein's criterion and found a significant effect of UCS intensity upon performance. Therefore, there seems little doubt that there is a positive relationship between UCS intensity and performance.

Intensity and percentage reinforcement

The data from the investigations of varying UCS intensity with percentage reinforcement in human eyelid classical conditioning are conflicting. Ross and Spence (1960) re-evaluated a number of studies in order to establish a relationship of percentage reinforcement of UCS intensity. The shapes of the functions are quite different for the two reinforcement schedules. With continuous reinforcement, the function is negatively accelerated with small increases in puff strength at low absolute levels resulting in large increases in performance. In contrast, under 50% reinforcement, the function is S-shaped with

little performance change over the low range of UCS intensity values. In addition, the rise in performance is gradual and the asymptotic level is much lower for the 50% reinforced group. Fishbein (1967) found CR performance positively related to UCS intensity, whereas Boice and Boice (1966) and Runquist (1963) found the reverse. Gormezano, Moore, and Deaux (1962) found a positive relationship using a yoked comparison technique but, as Spence and Platt (1966) indicated, one obtains a confounding of the UCS intensity level with the PR variable.

... as UCS intensity increased, the performance level of avoidance Ss increased so that their yoked classical controls received fewer reinforcements. The effect of this partial reinforcement was sufficiently strong to produce an inverse ordering of the classical groups on the UCS intensity dimension
(p. 4 - 5)

Since the data using these variables is contradictory, further research is required.

Purpose

To recapitulate, no studies to date have investigated the interaction of percentage reinforcement and UCS intensity with infrahumans. The purpose of this experiment is to investigate the influence of these variables upon extinction of the classically conditioned eyelid of the rabbit. The experimental design was a 3 x 2 factorial with one replication. Three levels of the UCS intensity were combined with CRe and PR Ss. The data from this experiment a) enabled us to see if Thomas and Wagner's results held over all intensity levels, and b) yielded parametric data of UCS intensity and percentage reinforcement for the rabbit.

Subjects

The Ss were 48 naive, male and female, New Zealand albino rabbits, 80 to 100 days old, which were obtained from a local farm. Each S was housed in a separate cage, and had free access to food and water.

Apparatus

Two Ss were run simultaneously in separate cubicles. The conditioning apparatus was similar to that employed by Gormezano (1964). Briefly, S was placed in a wooden restraining box with its head inserted through an opening in the front. The pinnae of both ears were clamped to the top of the box to prevent gross head and body movements from taking place (cf. Fig. 1 and 2).

The technique for recording the responses was modified from that described by Gormezano (1964). Two Clarex CL503A photocells were used. Each of the photocells was in series with a fixed resistor so as to form two voltage dividers (Fig. 3). The output from each divider was fed into the differential input of a Brush Mark II Ink Writing Oscillograph. The output from the dividers was balanced by means of a potentiometer which varied the potential applied to the two circuits.

The two cells were positioned in the following manner. One cell (EC) was directed toward, and 1/2 inch away from, S's eye with the other cell directed toward the fur near the eye. With S's eye open, a steady output was produced by the cells. When the eye closed, the reflectance properties of the rabbit's eye would change, thus changing the resistance of EC. This, in turn, would change the output of the two cells.

An event marker on the Oscillograph recorded the onset and termin-

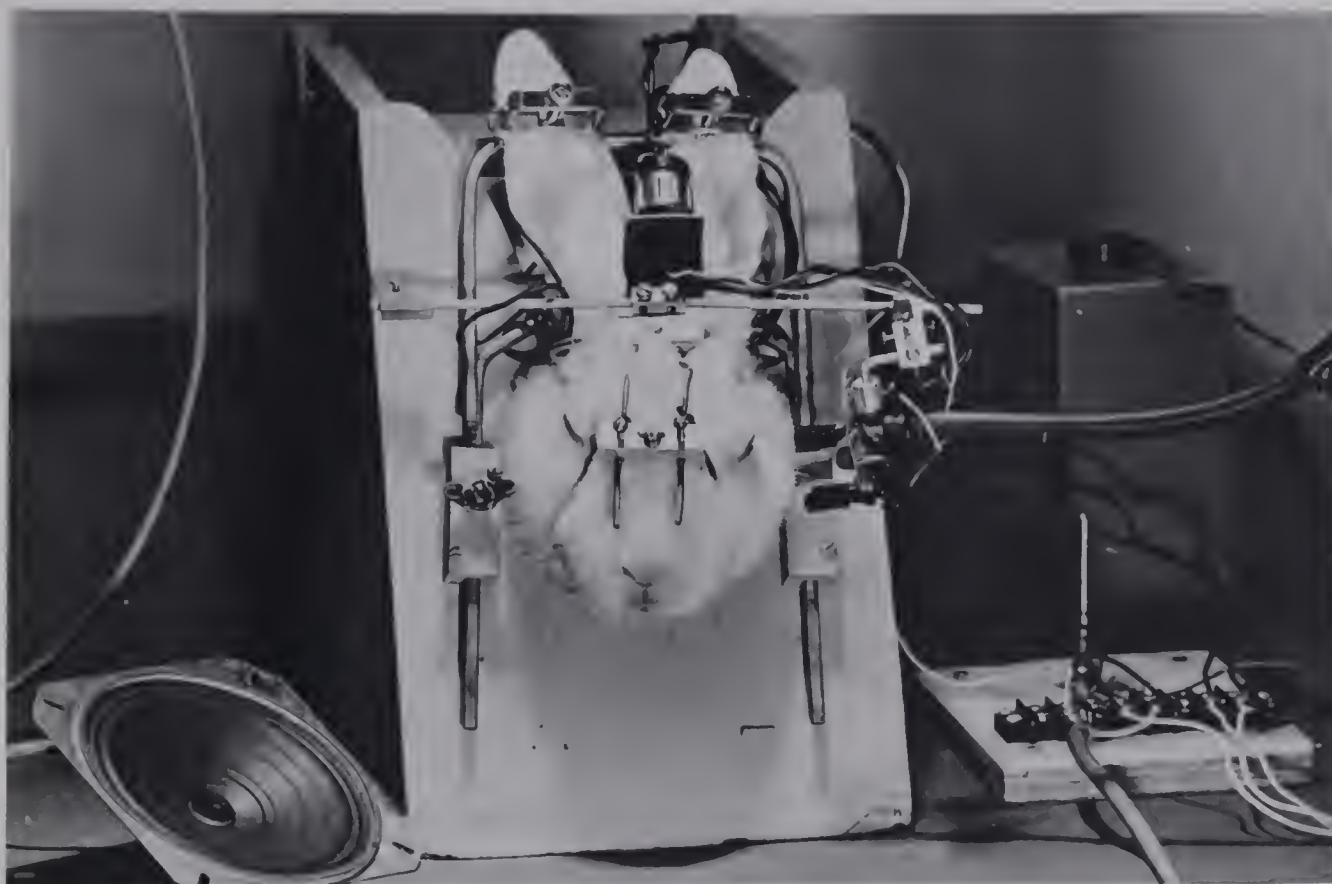


FIGURE 1 Rabbit in restraining box with headgear attached



FIGURE 2 Close-up view of the headgear

ation of the CS. The graphic paper speed was 125 mm/sec. A Convair Paper Tape Reader selected the type of trials and controlled the inter-trial intervals of 530 msec. Hunter Decade Timers controlled the CS-UCS interval and duration. Because of the large number of recording trials that were involved, only selected blocks of twenty trials were recorded in order to conserve paper. The trials involved were 1-20, 41-60, 61-80, 101-120, 161-180, 221-240, 281-300, and 341-440 during acquisition and all trials during extinction. The UCS was a 100 msec puff of compressed nitrogen delivered through a 1 mm diameter orifice to S's eye, at a distance of 3/8 inch from the cornea. The intensity of the airpuff, measured at its point of delivery to the cornea, was of sufficient intensity to support a 75, 150, or 250 mm column of mercury. The CS was a moderately loud 1000 cps tone generated by a Smith Model 2425 code practice oscillator, which terminated with the offset of the UCS. The tone was presented to the rabbit by a speaker.

Procedure

On the day of their arrival, the Ss were given two 1-hour adaptation sessions to the apparatus. Each S was restrained in the wooden box with the head-gear attached.

The Ss were then assigned to one of six groups. On sessions three to nine, inclusive, each S was given acquisition trials. Each session the CRe Ss received 60 CS-UCS pairings, while the PR Ss received 30 CS alone and 30 CS-UCS trials presented randomly with the restriction that no more than two CS alone trials occur consecutively. On the tenth session, all Ss were given an additional 20 acquisition trials; 20 CS-UCS trials for the CRe Ss, and 10 CS alone and 10 CS - UCS trials for

the PR Ss. Then, all Ss received 60 CS alone trials.

The intertrial intervals during acquisition and extinction were varied among 55, 60 and 65 sec in a random order averaging 60 sec.

Deflections of the recording pen of 1 mm or more from the baseline and occurring from 25 msec after CS onset to 25 msec after UCS onset during acquisition and extinction were considered to be CRs.

Acquisition Data

The results of this experiment are summarized in Figure 4. The CRe Ss performed better than the PR Ss in all cases, and their performance increased as increases in the UCS intensity were presented. The most striking feature is the low level of conditioning attained by most of the Ss. The maximum value attained for the CRe and the PR Ss was 45% and 17% respectively. The rise of the 150 PR Ss resulted from the rapid conditioning of a number of Ss in the last block of 20 acquisition trials.

The summary of the analysis of variance appears in Table 1. Both the percentage reinforcement and trials variables were significant ($p < .01$). The intensity variable was not significant. Of the interactions, only the percentage reinforcement x trials was significant ($p < .01$). The CRe Ss performed better than the PR Ss over all the acquisition trials.

This analysis was undertaken when trials were equated for both the CRe and the PR Ss. The PR Ss received half as many reinforcements, but, because of the difference in the number of reinforcements, it can be argued that one should expect a lower performance level for the PR Ss. Since they have had fewer conditioning trials, it could be argued that their habit strength should be less. If they were given the same number of reinforcements as the CRe Ss, their performance level might then be the same. Table 2 presents an analysis of the data when the reinforcements to each of these two groups were equated. The mean CR's are shown in Table 3. A significant difference was found between them. This differs from the finding reported by Thomas and Wagner

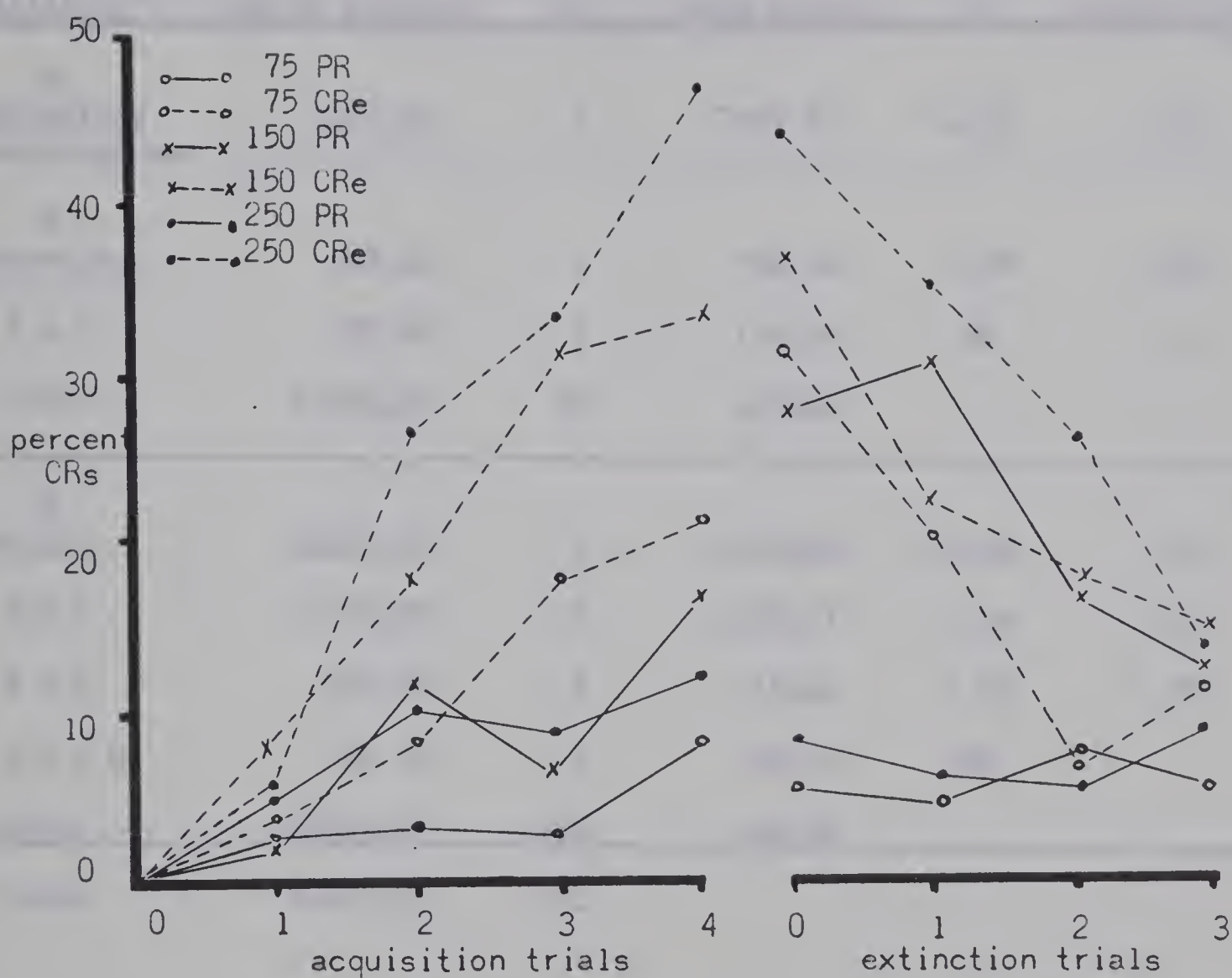


Figure 4 Mean scores of acquisition and extinction data. Acquisition data is presented in blocks of 110 trials. Extinction data is presented in blocks of 20 trials. The first points plotted under 0 of extinction refer to the last block of 20 acquisition trials.

Table 1

Summary of analysis of variance of acquisition data
with trials equated.

Source of variation	Sum of squares	df	mean square	F	probability
A					
percentage reinforcement	3467.55	1	3467.53	12.21	< .01
B					
intensity	109.23	2	546.12	1.99	> .05
A x B	289.88	2	144.94	NS	----
error	11922.81	42	283.88		
C					
trials	12636.90	3	4212.30	38.18	< .01
A x C	3176.02	3	1058.67	9.59	< .01
B x C	684.45	6	114.08	1.03	> .05
A x b x C	528.19	6	88.03	NS	
error	13901.44	126	110.33		
total	47699.45	191			

Table 2

Summary of analysis of variance of acquisition data
with equated reinforcements.

Source of variation	sum of squares	df	mean square	F	probability
A percentage reinforcement	2552.08	1	2552.08	4.30	<.05
B intensity	1946.47	2	973.24	1.64	NS
A x B	306.93	2	153.47	0.26	NS
within	24986.19	42	594.10	--	
total	29791.67	47			

Table 3

Mean percent CRs given by CRe and PR Ss when reinforcements
were equated

% reinforcement		CRe		PR	
trials		221-240	261-280	361-400	401-440
UCS intensity	75	34	28	10	26
	150	23	13	10	7
	250	35	33	12	11

Table 4

Summary of analysis of variance of extinction
data with trials equated

source of variation	sum of squares	df	mean square	F	probability
A percentage reinforcement	86.42	1	86.42	6.59	< .05
B intensity	68.70	2	34.35	2.62	> .05
C trials	83.99	2	41.99	3.19	< .05
A x B	74.24	2	37.12	2.83	< .05
A x C	22.12	2	11.06	-----	
B x C	13.59	4	3.39	-----	
Ax Bx C	64.22	4	16.05	1.22	> .05
within	1652.00	126	13.11		
total	2065.28	143			

(1964). However, a comment is necessary. The trials involved in this comparison should have been 401 to 440 for the PR Ss and 201 to 220 for the CRe Ss. The actual recorded responses were from trials 221 to 240. However, it is unlikely that the bias which was in favor of the CRe Ss, produced the difference. An inspection of the slope of the curve determined from Table 3 indicates the CRe Ss gave more CRs than could be accounted for by the bias.

Extinction data

The extinction data are summarized in Figure 4. The CRe Ss extinguished quite rapidly. Comparison with PR groups is difficult with one exception. The 150 PR Ss appear to extinguish at the same rate as the CRe Ss. The summary of the analysis of variance is presented in Table 4. The percentage reinforcement and trials variables were significant ($p < .05$). There was a significant difference between the CRe and the PR Ss in their overall performance. The percentage reinforcement x trials interaction was not significant. There was no significant difference in the rates of extinction of the CRe and the PR Ss. The percentage reinforcement x intensity interaction was significant ($p < .05$), but the percentage reinforcement x intensity x trials interaction was not significant. The different UCS intensities had different effects on the CRe and the PR Ss, but when the analysis was considered over trials, this difference disappeared. From the above analysis one could conclude that no PRE was found.

The raw data of this experiment yields only relatively small differences. This resulted from the low performance level attained by most of the Ss, particularly the PR Ss. Consequently, the analysis of vari-

ance of the raw data may not have been sensitive enough to detect any difference that might have occurred. Therefore, an analysis in terms of loss scores was undertaken. Two types were attempted: the absolute loss and the percentage loss.

The main scores from the data for the absolute loss are presented in Figure 5 and Table 5. The absolute loss was computed by subtracting the number of responses occurring during each extinction trial from the number of responses occurring during the last block of 20 acquisition trials. The CRe Ss showed the greatest absolute loss. The PR Ss, excepting the 150 PR Ss, showed a slight gain. The analysis of variance of this data is summarized in Table 6. Here, the percentage reinforcement and trials variable were significant ($p < .01$). The interaction of percentage reinforcement \times trials was not significant. Thus, no PRE was found. This finding again supports Thomas and Wagner's (1964) study. The interaction of percentage reinforcement \times intensity \times trials was significant ($p < .05$). Since the 75 PR and the 250 PR groups showed little acquisition, the significance of this interaction seems due to the fact that no loss was possible in these conditions and therefore, does not really reflect a PRE with these two UCS intensities.

The analysis of variance using both the raw data and the absolute loss data favorably bias the possibility of finding a PRE. The PRE in this study is defined in terms of an interaction between the CRe and the PR Ss over trials. The bias occurs because of two inherent difficulties in using the constant trials method of experimentation. The first difficulty is that, during acquisition, the performance level of the PR Ss is usually lower than the performance level of the CRe Ss. The second diffi-

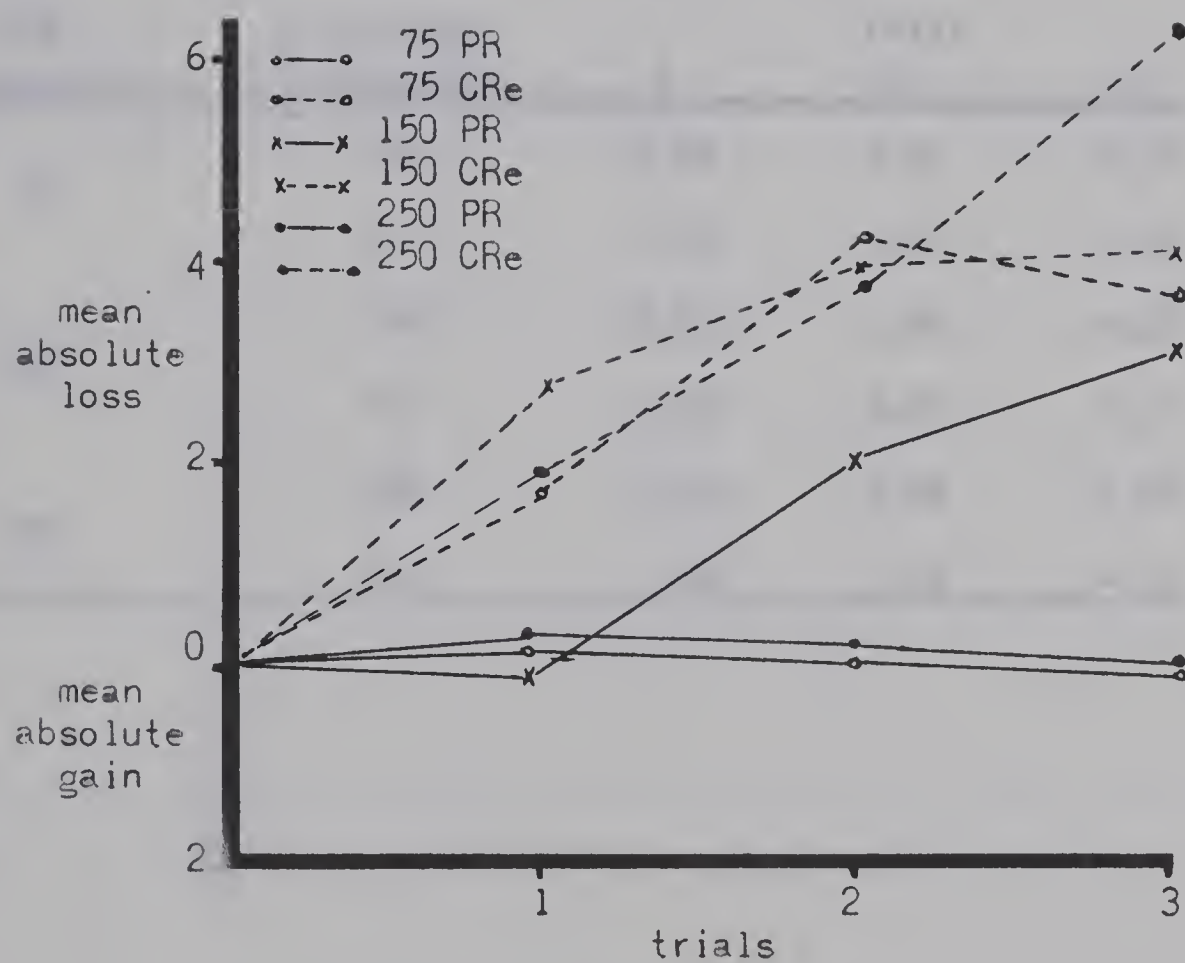


Figure 5 Mean scores of absolute loss.

Table 5

The mean absolute loss occurring during
the extinction trials

UCS intensity	percentage reinforcement	1	2	3
75	CRe	1.63	4.50	3.75
	PR	.13	-.63	-.13
150	CRe	2.63	3.88	4.25
	PR	-.50	2.00	3.13
250	CRe	1.88	3.88	6.25
	PR	.50	.63	-.13

Table 6

Summary of the analysis of variance using the
values from the absolute loss data

Source of variation	sum of squares	df	mean square	F	probability
A percentage reinforcement	339.16	1	339.16	8.05	< .01
B intensity	21.50	2	10.75	-----	NS
A x B	16.45	2	8.23	-----	NS
error	1778.04	42	42.32		
C trials	84.64	2	42.32	10.38	< .01
A x C	21.48	2	10.74	2.63	> .05
B x C	16.87	4	4.22	1.03	> .05
A x B x C	67.59	4	16.89	4.14	< .05
error	343.09	84	4.09		
total	2688.82	143			

difficulty again concerns the PR Ss. Here, during extinction, the PR Ss lie nearer the horizontal axis, their lower limit. If the performance of the PR Ss were to parallel the performance of the CRe Ss, then it would reach this lower limit prior to the conclusion of the extinction trials. The performance would then proceed parallel to the horizontal axis, that is, the performance of the PR Ss would be zero or nearly zero for the remainder of the extinction trials. The result is that the performance of the two groups of Ss converge as extinction trials are administered, thus favoring an interaction. An attempt was made to partially overcome this difficulty by considering the percentage loss. The difficulty would be overcome because the loss would be measured independently of Ss's performance level. In this case, the figures were computed in the following manner:

$$\text{percentage loss} = \frac{X - Y}{X}$$

where X = the number of responses occurring during the last block of 20 acquisition trials, and Y = the number of responses occurring during each extinction trial. If X = 1 and Y = 0, then there has been a 100% loss in performance. However, this measure could not be used because a large number of Ss showed zero scores in the last block of 20 acquisition trials, particularly in the 75 and 250 mm groups.

A further analysis of variance (Table 7) was undertaken to compare the 150 CRe Ss with the 150 PR Ss. The reason for this analysis was that it was only with the 150 PR Ss that virtually any conditioning was obtained under the partial reinforcement conditions. It was realized that this analysis was not an orthogonal comparison and that it was post hoc, but it was felt that in view of the acquisition

Table 7

Summary of the analysis of variance for the extinction
data of the 150 CRe and the 150 PR groups

source of variation	sum of squares	df	mean square	F	probability
A percentage reinforcement	49	1	49	1.86	>.05
C trials	58	2	27	1.02	>.05
A x C	9	2	4.5	0.17	>.05
error	1109	42	26.4	----	
total	1225	47			

data the finding would be of some interest. In this case, the percentage reinforcement \times trials interaction was not significant. The two groups extinguished at the same rate.

The results of this experiment agree with those of Thomas and Wagner's (1964) study in that no PRE was found. The percentage reinforcement x trials interaction was not significant in the analysis of either the raw data or the absolute loss data. Although the percentage reinforcement x intensity x trials interaction was significant in the analysis of the absolute loss data, it was felt that this interaction did not adequately reflect a PRE because of the low level of performance attained by the PR Ss during acquisition. In this case, little loss was possible in some of the PR groups. Higher levels of performance might have been obtained if more trials had been given during acquisition, but this was not feasible in the present study. In one group, however, the 150 PR, Ss showed sufficient conditioning to enable a determination of the effect. Again no PRE was found.

The acquisition data from this study differs from that found in Thomas and Wagner's study. In their study, both the CRe and the PR Ss attained the same level of performance, whereas in this study, there was a significant difference between the two groups. This latter finding is similar to that of Ross and Spence (1960) and others using the human eyelid response. When reinforcements were equated within the acquisition data, a difference still appeared between the CRe and the PR Ss. A bias was present, which slightly favored the CRe Ss, but it was unlikely that the difference was solely a result of this bias.

The relationship between percentage reinforcement and the level of conditioning seems valid. The CRe Ss performed better than the PR Ss. However, the UCS intensity effect may not be valid because the low per-

formance levels in the PR groups did not allow the performance variability due to the different UCS intensity levels to develop. This effect, however, is suggested by the CRe acquisition data. Here, with increasing UCS intensity levels one obtains increasing levels of performance.

The finding of the superior performance of the 150 PR as compared to the performance of both the 75 PR Ss and the 250 PR Ss during acquisition is difficult to explain. This difficulty may arise from the expectation that the relationship between UCS intensity and performance is a linear one. But, the relationship may, in fact, be complex. This possibility is also suggested by a consideration of the results from the studies of Boice and Boice (1966), Foth (1968), and Runquist (1963).

This study has a number of interesting parallels to those using human Ss. The acquisition curves are similar but conditioning occurs at a much slower rate. The CRe Ss perform better than the PR Ss and the intensity variable has no effect with random partial reinforcement (Runquist, 1963). If only the CRe Ss are considered in the analysis, the data suggested that performance increases with increasing UCS intensity values. This is consistent with traditional findings.

The parallels during extinction are more complex. If one considers only the data from the 150 CRe and the 150 PR Ss, then no PRE effect occurs. This is in line with Thomas and Wagner's study and tends to support Spence's theory concerning the PRE. Although the percentage reinforcement \times intensity \times trials interaction was significant, this interaction, as was previously mentioned, does not adequately

ly reflect a PRE.

Important in the interpretation of these results is the consideration of two different viewpoints.

1. The obtained results are valid and adequately reflect the processes that are taking place.
2. The low level of conditioning attained by all groups, during acquisition, suggested that a number of distracting influences were probably present during the running of the experiment.

There is one item of evidence which supports the first viewpoint (Ross and Spence, 1960). This study has been described in the introduction. Ross and Spence's suggestion that an inhibitory factor operated on the PR Ss suggests the reason for the low performance of the PR Ss in this study. Also, excepting the 150 PR Ss, the CRe Ss performed better than the PR Ss and the performance increased with increasing UCS intensity values. However, the suggestion that inhibition is operating applies only to the low UCS intensities and does not explain why little conditioning was observed for the 250 PR Ss except to note that Foth (1968) found an inverse relation between UCS intensity and performance under PR. Therefore, it is evident that more emphasis should be placed upon the second viewpoint. The remainder of this discussion, then, will be devoted to a consideration of what distracting influences might have been operating during the running of this experiment.

At the conclusion of 440 trials, the mean percentage CRs for the CRe Ss was 34 and was 12 for the PR Ss. The difference in the level

of conditioning can be seen when the data is compared to that of Bruner's (1965) results where his Ss attained a level of 53% and 27% CRs for the CRe and the PR Ss, respectively. However, Bruner was measuring the nictitating membrane response which reportedly results in a higher percentage of CRs (Gormezano, Schneiderman, Deaux, and Fuentes, 1962). Further comparisons can only be made for the CRe Ss. Using the eyelid response of the rabbit, Schneiderman, Fuentes, and Gormezano, (1962) attained a level of 55% CRs. Gormezano, Schneiderman, Deaux, and Fuentes (1962), Schneiderman and Gormezano (1964), and Papsdorf, Fishbein and Gormezano (1964) each attained a level of 81%, 91% and 71% CRs, respectively, using the nictitating membrane response. In a previous pilot study with four rabbits, the CRe Ss attained conditioning levels ranging from 72% to 88% CRs. No PR Ss were included and only one intensity value was used (150 mm).

Several factors may account for the low performance level reached by most of the Ss.

1. During the actual running of the experiment, the rabbits in the restraining box had to be calmed down frequently during periods of violent struggling. This would suggest that the rabbits were not adapted to the box, although the normal, known training procedures had been followed. Since the running of this experiment, new techniques are being used for the taming procedures (Frey and Ross, 1967 and 1968). Six adaptation sessions instead of the usual two were found to produce less activity and better performance.
2. A 12-volt lamp was used to provide the illumination for the

photocells. The heat from this lamp, plus the failure of the rabbits to adapt to the box may have produced sufficient cause to distract the rabbits.

3. There may be strain differences with the New Zealand albinos, as exists with rats, to produce significant differences in performance.
4. Rescorla (1967) has suggested that it is the contingency between the CS and the UCS rather than the pairing of the CS and the UCS which is the important event in Pavlovian conditioning. Contingency, here, includes what is, and what is not, paired with the CS. Prokasy (1965) suggested that an S-S association is frequently made very early in the conditioning session and that the results of this association may be shown in a variety of ways and, often, not until after the occurrence of many trials. The response that appears is under control of the S. (This observation is implicit in Rescorla's argument). However, the response which S evokes may not be the response which the experimenter is measuring. In terms of this experiment, the Ss may have formed the association between the tone and the airpuff but were responding in immeasurable ways.

The only clear results from this experiment were found with the acquisition data. The CRe Ss performed significantly better than the PR Ss. It was also suggested that UCS intensity may be related to performance, at least with continuous reinforcement. It was decided that no justifiable conclusions could be made based on the extinction

data. More information about the conditions necessary for the appearance of the PRE is required. In this regard, further experimentation should control for the variables suggested above. An evaluation of Spence's theory, therefore, must wait until stable conditioning levels can be attained.

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